

the mean of the six differences to represent the solar intensity of the month. The result, as will be seen from the following table, is in complete accordance with that previously arrived at from other data. The same thermometer has been in use throughout.

TABLE V.—*Solar intensity at Darjiling.*

STATIONS.			1870.	1871.	1872.	1873.	1874.	1875.
January,	..	..		57·8	67·7	59·2	57·8	62·3
February,	..	..		62·2	62·8	62·3	56·5	60·3
March,	..	..		63·3	63·5	62·	58·2	57·8
April,	..	..		64·2	63·2	62·8	55·7	60·2
May,	..	..	62·2	67·8	66·8	63·8	59·8	
June,	..	..	67·	68·	67·3	62·5	59·2	
July,	..	..	63·3	66·2	65·7	60·8	56·3	
August,	..	..	70·8	65·7	66·8	60·	57·8	
September,	..	..	71·5	69·3	63·7	62·3	59·3	
October,	..	..	65·5	68·2	70·	63·3	60·8	
November,	..	..	62·5	67·3	62·5	57·3	63·3	
December,	..	..	59·	66·3	59·	53·8	60·5	
Year,..				65·5	64·9	60·8	58·6	

VII.—*Notes on the Geology of part of the Daffla Hills, Assam ; lately visited by the Force under Brigadier-General STAFFORD, C. B.—By Major H. H. GODWIN-AUSTEN, F. R. G. S., F. Z. S., &c., Deputy Superintendent Topographical Survey of India.*

(Received June 18th,—Read July 7th, 1875.)

(With Plate VI.)

My survey duties with the late expedition into the portion of the Eastern Himalaya known as the Daffla Hills gave me an opportunity of making a few notes on the geology of this portion of the North-eastern frontier, of which so little is known up to the present time.

From the Brahmaputra near Bishnáth and Dunsiri Mukh, the outer range of the Tertiary sandstones is well seen, the steep scarps shewing white against the dense forest with which they are covered. I first entered this outer range by a route up the bed of the Darpang stream, a tributary of the Pichola, when proceeding to clear the hill Dihirhi Párbat for a Trigonometrical station. After leaving Borpathar, the road leads over the plain in a direction WNW., and after 5 miles the shallow bed of the Darpang is followed up and leads directly by a narrow gorge into the hills: these rise suddenly from the level plain of recent detritus, no outlying beds of later age being seen here.

The strata dip about 20° NW., and consist of thick-bedded fine sandstones with strings of water-worn pebbles here and there, but no conglomerate was seen; they weather on the higher ridges into spheroidal masses indented with small holes, in a precisely similar manner to the upper sandstones of the Burrail range. The most conspicuous beds are of a very pale grey colour with black grains. Pieces of lignite are commonly found *in situ* and lying in the beds of the water-courses. The ravines are bounded by very steep sides, and are deep and gloomy. Looking from Dihirhi Párbat westward, the fringing range of the sandstones is well seen, rising at Gorusutia or Peak 1 of the G. T. S. into a sharp scarped point 3,319 feet high, but the ridge descends here and there on the line of strike to below 1000 feet. It presents the same feature all along of a steep scarp towards the plains, and of a slope dipping 20° — 25° NNW. towards the main mass of the mountains on the north, from which it is separated by a broad valley or “dhún” drained by the Pomah. This dhún is cut up by numerous ravines and low ridges all buried in dense forest.

To the eastward, 3 miles from Dihirhi Párbat, the sandstone ridge is much subdued. A change takes place in the strike of the mountain mass, and a broad forest-clad plateau, much intersected by ravines and about 200 feet above the plains, extends as far as the gorges of the Dikrang at Harmatti. On this side, the Borpani and Dikrang on their SW.—NE. courses represent and take up the continuation of the Pomah Dhun. At Harmatti is seen another quite recent deposit, in an alluvial plateau of sand, clay, and boulders, on which land for a tea-garden has been taken up. It corresponds to similar terraces in the Western Bhutan Duars, as those on the Jholdaka, &c., but is nowhere more than 30 to 40 feet above the river bed, and is found fringing the older rock slopes for some distance up the valley and to the eastward. It lies against a broad extent of very low intricate hills, which, from this towards the east, are a conspicuous feature. The very hurried examination I was able to make of these beds near Harmatti shewed them to be ferruginous-coloured sandstones and thick conglomerate beds resting on fine blue grey sandy beds dipping 5° to South-eastward. No lignite was seen *in situ*, but rolled pieces were common in the bed of the stream, evidently brought down some distance. At Harmatti similar beds dip 15° SE.; they appear to me to represent the newest beds of this Tertiary series, here extending out into the plains beyond the strike of the 1st or Dihirhi Párbat line of elevation. This line is taken up again east of the Dikrang by a low ridge which bounds the river on the SE. as far as the great bend it takes 10 miles above the junction of the Borpani.

Leaving the stockade at this junction, the winding bed of the Sibjúli is followed, and this $1\frac{1}{2}$ miles farther is joined by the Niosi, a much larger stream. In the bed of the last, the gravels are found to be a great mixture

of gneiss, clay shales, and dark-coloured sandstones belonging to a different series of rocks, with a few pebbles from Tertiary sandstones, shewing that the river must cut through the whole series of stratified rocks up to the metamorphics. This I afterwards found to be the fact. I found here several pieces of silicified wood (a large grass) 8 inches in diameter. The first exposed section, seen about four miles further up the Sibjúi, presented the Tertiary sandstones with a high dip, 75° SE by S. : these are here very dark and hard, thick-bedded, with a slight violet tint. They contain no pebbles, and are of a different character from the outer or Dihirhi group of beds. At the low pass over into the Harjúi they are thin-bedded, softer, and vertical. Passing on northward, on the SE. spur from Tánir Peak, the sandstones are horizontal, and evidently roll over at the Peak to 35° NW., which is the dip all along the crest of this second ridge. Crossing it and proceeding down the spur to the Dikrang, at the few places where the sandstone is uncovered, the dip has become high to the North-west-ward.

But it was on the Dikrang itself that the most interesting section was obtained. On following up the first and eastern stream on the right bank of that river near Camp No. 6, below the village of Shikhi (Phekfis), the first trace of an older series of rocks was found, about a quarter of a mile up the bed, where a dark, hard, heavy sandstone occurs, vertical with a NE.—SW. strike. The soft Tertiary sandstones immediately succeed, having a local dip E. by S. 75° : they are much crushed, very thick-bedded and micaceous, with scattered small pebbles, and they appear the equivalents of the sandstones of Dihirhi. Proceeding up the bed of the next stream (the largest, which I shall, for the sake of distinction, call the Tánir júi, because it drains the northern face of the Tánir ridge), we first come upon the Tertiary sandstones nearly perpendicular, strike SW.—NE. ; a very few yards further on are clay shales, very dark and carbonaceous, dip 70° high, NW. Some 50 yards further up the stream, the dip was reversed to 75° ESE., with considerable crushing, and here occurred a thick seam of black carbonaceous shale 5 to 6 feet thick, interstratified with dark close-grained sandstones ; this can be traced along the strike NNE.—SSW. for 200 yards, as it crosses the bed of the stream three times. It is rather a crushed splintery coal than a shale, and no doubt would prove better below the surface. Where now exposed it is either in the water or just out of it, in fact, to see it at all one has to wade up the bed of the stream, the jungle on the banks being too thick to move about in.

It was most interesting to come on these rocks in this position, as they are no doubt the representatives of the Damúda Series lately examined and worked out along the base of the Darjeeling and Western Bhútán mountains by Mr. F. R. Mallet,* and first noticed by Dr. J. D. Hooker in 1849, near

* Memoirs of the Geological Survey of India, Vol. XI, Pt. I.

Pankabári. The coal seam has exactly the flaky structure described by Mr. Mallet. The crushing to which it has been exposed has apparently altered its original and probably even thickness, both the upper and lower surfaces being waved irregularly, so that it never retains the same thickness for many yards together along the strike. I could not find time to follow the ravine further, but, at the head of the valley, a full section of these beds would be found along the low ridge connecting the Tánir Lampah with the Misa Párbat ridge. The boulders and gravel consisted principally of (1) the hard sandstone of a pale blue slaty colour, the darkest often speckled with minute grains of quartz (?); (2) a few of the soft Tertiary sandstones, but these apparently soon get ground away; (3) a very hard lighter coloured rock of the Damúda Series; (4) some hard conglomerate; and (5) a few of gneiss from the ridge on the north side of this valley, on which is the little hamlet of Dápú.

I am inclined to think there is unconformity between this Damúda series and the sandstones, but the crushing is great and renders it very difficult to make out clearly; exposed sections being so very scarce. There cannot, however, be here a greater thickness of Damúdas than 1000 feet in the area intervening between the sandstones and the quartzites and gneiss. Overlying the denuded outcrop of the Damúdas, in this lateral valley, is a mass of sandy clay and large sub-angular blocks (some 15 feet long) of the harder strata and quartzitic sandstones, &c.; this, combined with the dense forest, affords a geologist few opportunities of seeing much. The Tánir júli marks the junction of the stratified rocks and the metamorphic series, for some distance, by its wide open valley, the breadth corresponding with the outcrop of the whole Damúda series. The valley of the Dikrang corresponds with the continuation of this outcrop for a long distance to the NE.; its very probable extension westward is marked on the map by several streams excavated on the main line of strike, along the base of the gneissic rocks.

Having once found this thick carbonaceous seam,* it was very easy to follow it up. It crosses the Dikrang in a NE. direction and shews on the left bank close to the suspension bridge, beyond which it leaves the river and becomes covered up with alluvial deposits. Down the Dikrang from this spot, a set of very hard compact sandstone strata, perpendicular and shewing metamorphism, is exposed along the bed of the river, and, about half a mile down, their junction with the unaltered soft Tertiary sandstones is capitally displayed on the right bank. The latter rocks have a high southerly dip, and although having the same strike, gave me a still stronger impression of their unconformity.

* This coal would have to be worked up into an artificial fuel, such as is described by Mr. Mallet at page 60 of his memoir.

To the Damúdas, quartzitic beds succeed, some very white, but I nowhere found an actual contact. On the road to the bridge built by the force above Camp No. 6, a dark green rock is conspicuous by its very trappean appearance: at the bridge a very white quartzite underlies it, dipping 55° SE. These metamorphic rocks have a regular strike SW.—NE., nowhere better seen than from Zorúpútú; that peak with the peaks of Dorkorpútú and Shengorh lying in the main axis of elevation in a true NE.—SW. line. The metamorphics seem to pass by degrees into micaceous schists and hornblendic gneiss (which was noticed 3 miles above the bridge), and then into true granite with large feldspathic crystals, very similar to that of the North Khási Hills, at the Kollong rock, &c. The peaks of Misa Párbat and Shengorh are of this granite. Near Camp 9, under Nanang's village, the gneiss was very talcose, talc occurring in pieces of an inch square or more. The quartzites, mica schists, &c., probably represent Mallet's "Daling Series."

River-terraces of Recent Age.—Near the junction of the Tánir júli with the Dikrang, a higher and a lower terrace are well-marked features: they are composed of sand, clay, and large transported blocks, more or less rounded. The lowest is well seen on the left bank about 20 feet above the river bed at Camp 6. The highest, between that and the bridge about one mile above, has a thickness of some 125 feet. Their deposition here no doubt occurred during the period of glacial extension throughout the Himalayan Range, and they would naturally have accumulated more at the junctions of large lateral valleys than elsewhere. The remains of these terraces are to be traced at intervals up the valley, notably at Pachitah, but the highest is not seen in the valley below Nanang's village and above the junction of the Níumtay.

The Burroi Gorge.—At the deep pool where the Tertiary sandstones are first seen on the left bank there is an interesting section. The beds are dipping about 50° towards the plains; the denuded surface is smooth and undulating, and here not more than 8 to 10 feet above the water level (March). Proceeding up the river about a quarter of a mile to the next large pool, the same section is again seen, but the upper surface of denuded sandstone is there quite 15 to 20 feet above the river, shewing a very considerable slope of the old earth-surface from the hills. On this surface rests a very recent series of iron-coloured sands and gravels, quite 60 or 70 feet thick, nearly horizontal, but the very slight incline is towards the Southward. These beds abut against the older rocks, which soon commence to rise into well-marked spurs from the outermost range.

These comparatively recent deposits are no doubt the same as those composing the plateau at Beháli Tea-garden, miles out in the plain towards the Bramaputra, and also of the Bishnáth plain. About 300 yards below

the first deep pool (where our camp was pitched), near the head of the next rapid, the last of the Tertiary rocks is exposed in the water and about a foot out of it, and dips south about 70° , the strata apparently falling over into a sharp uniclinal. This feature I have introduced into the section from Harmatti to the Tánir Ridge as it probably extends along the whole base of the hills, but is covered with the more recent alluvial deposits.

To the west of the Burroi, the sandstone range has a general dip NE., but a very conspicuous longitudinal roll occurs at the second large ravine west of the main gorge. The strata immediately east of this ravine dip 50° W., while in the main gorge of the Burroi they have a general easterly underlie, but are a good deal crushed and exhibit high dips. To the west the beds are much less disturbed and again assume regular dips of 30° to 40° northerly, the whole series gradually ascending towards Gorusutia to the main longitudinal axis of elevation. Looking at the hills 20 miles to the west of the Burroi, the dip of the lowest outer range appeared 20° southerly, producing a long even slope towards the plains.

The Bisnáth Plain.—I first came on this remarkable portion of the country, on the road between Rangali and Burigaon, just after crossing the Borgang, which has a wide sandy bed, but a volume of water not more than half that of the Burroi. The rise is sudden out of the “kadir” land of the former river, and about 20 to 25 feet, succeeded at from 200 to 300 yards by another of perhaps 3 feet, but very distinctly marked. The surface is perfectly flat, covered with a thin growth of grass, a few of the highest stalks of which may be about 6 or 7 feet high, but it is a short grass for Assam. Patches of forest of a few acres in extent are dotted about here and there, their limits very defined and generally round or oval in shape. The plateau ends abruptly on its southern side, towards the Brahmaputra, but its edge is irregular in outline, having been scooped into by the river in its wanderings from side to side. Traces of the former channel occur in the re-entering angles, in long crescentic pieces of water fringed with marsh and high reeds and grasses; these extend mile after mile to the main river. The view from the plateau, especially off the back of an elephant, is very fine, the dead level surface stretching afar, the line of horizon only broken here and there by a solitary tree or by the embankment of some old tank, for the day has been when all this area was thickly studded with villages. The low scarps of the dry nulla east of Burigang rest-house shew that there the plateau is sandy, and small rounded pebbles, mostly of quartz, occur quite near the top of the section. On the Sudoro, however, away from the influence of the ancient Borgang, red clay predominates, as well as in the scarp to the west of Partabghar, where the plain of Bisnath ends. The thickness of the alluvium here appears much greater, but there is no

real increase; the Giladeri nulla has cut into the alluvium and flows at its very base, and, instead of the usual gradation of fall from terrace to terrace, the whole thickness is seen at once and amounts to some 40 feet. The high level of the Bisuáth Plain is seen from here to extend on the north and north-west by the tea-gardens of Diplonga and Dikro, and an isolated high patch of alluvium occurs about 4 miles west of Sútia, gradually falling by steps at long intervals into the present level of the land on both banks of the Barowli. A series of accurate levels taken over this country would be most interesting, but that it is of the same age as the clay plateau at Tezpúr and many other places in the Assam valley as far down as Gwálpára is certain. It could only have been formed under very peculiar conditions,—in still water, with the surface higher than it now is towards the delta, and with a far larger water supply from the mountains; gradual subsidence in the direction of the delta to the extent of a few feet and change of climate would soon model such outliers of an alluvium probably coeval with the extension of the Himalayan glaciers, the fine mud and sand from which would form just such clays and sands as the plateaus are composed of.

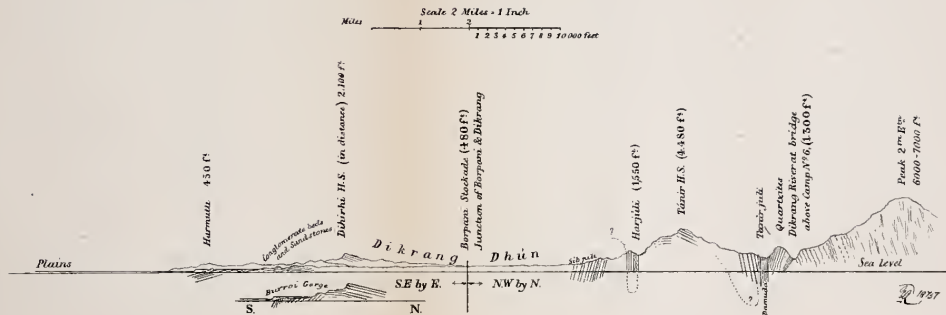


VIII.—*Note on the molluscan Genera Cœlostele, Benson and Francesia, Paladilhe, and on some species of Land-shells from Aden.*—By W. T. BLANFORD, F. R. S., F. G. S.

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In the 'Annali del Museo Civico di Storia naturale di Genova' for 1872, Vol. III, p. 5, is a description by Dr. A. Paladilhe of *Francesia*, a supposed new genus of Asiatic mollusks. As the typical form of the genus was found in India by Benson, a short notice of this paper may be useful to Indian naturalists, the more so as there is, I think, good reason for doubting whether the genus is really undescribed, and there are some details in the paper in question, and in a subsequent one, containing descriptions of some mollusca from Aden, which require correction.

The genus *Francesia* was proposed by Dr. Paladilhe for a small species found by M. Issel close to Aden, and recognised by its describer as identical with a specimen from the banks of the Jumna sent to him by Prof. Mousson. This Indian shell was received by Mousson from Benson under the name of *Carychium scalare*. M. Paladilhe relates at length the enquiries which he undertook in order to ascertain if this *Carychium scalare* was described, and after consulting various authorities, amongst whom were Messrs. Gwyn Jeffreys and Hanley, he concluded that it was not; Mr.



SECTION THROUGH THE OUTER DAFLA HILLS.

Photographed at the Survey General's Office Calcutta.